

CLAIMS

What is claimed is:

- 1 1. An apparatus comprising:
2 a mixer to convert an RF signal to a baseband-differential signal; and
3 a transconductance-capacitor (GmC) filter to filter the baseband-
4 differential signal, wherein the GmC filter comprises:
5 first and second transconductance-capacitor circuits in series and a
6 transconductance-feedback circuit in feedback with the second
7 transconductance-capacitor circuit.
- 1 2. The apparatus of claim 1 wherein at least one of either the first or
2 second transconductance-capacitor circuits comprises:
3 cross-coupled pairs of transistors to receive the baseband-differential
4 signal and generate a differential output current; and
5 first and second capacitors coupled respectively between differential
6 inputs of the at least one transconductance-capacitor circuit and first and second
7 internal-feedback nodes of the at least one transconductance-capacitor circuit.
- 1 3. The apparatus of claim 2 wherein the differential-output current is
2 substantially proportional to a differential-input voltage of the baseband-
3 differential signal, and
4 wherein the at least one transconductance-capacitor circuits further
5 comprises:
6 first and second current sources coupled respectively to the first and
7 second internal-feedback nodes to draw current through the transistors for
8 generating the differential output current; and
9 a feedback resistor coupled between the internal-feedback nodes.
- 1 4. The apparatus of claim 2 wherein the capacitors are voltage-dependent
2 capacitors, and

3 wherein during operation of the GmC filter, a substantially-constant bias
4 voltage is to be maintained across the voltage-dependent capacitors to allow the
5 voltage-dependent capacitors to provide a substantially constant capacitance.

1 5. The apparatus of claim 4 wherein the voltage-dependent capacitors
2 comprise metal-oxide-semiconductor capacitors (MOSCAPs), wherein the
3 substantially-constant bias voltage allows the MOSCAPs to be operated in a
4 high-density and low-variation portion of the voltage-dependent capacitors'
5 capacitance-response curve to provide a substantially constant capacitance as a
6 function of voltage thereacross.

1 6. The apparatus of claim 4 wherein the transistors of the cross-coupled
2 pairs comprise bipolar junction transistors (BJTs), and wherein the substantially-
3 constant bias voltage is to be approximately $2V_{BE}$ during the operation of the
4 GmC filter.

1 7. The apparatus of claim 4 wherein the transistors of the cross-coupled
2 pairs comprise field-effect transistors.

1 8. The apparatus of claim 1 wherein the GmC filter has at least two poles,
2 and
3 wherein the first transconductance-capacitor circuit is to provide a first
4 pole for the GmC filter corresponding to an output pole of the mixer, and
5 wherein the second transconductance-capacitor circuit and the
6 transconductance-feedback circuit are to provide a second pole of the GmC filter.

1 9. The apparatus of claim 1 wherein the transconductance-feedback
2 circuit comprises:
3 cross-coupled pairs of transistors to receive the baseband-differential
4 signal and generate a differential output current;
5 first and second current sources coupled respectively to first and second
6 internal-feedback nodes to draw current through the transistors for generating the
7 differential output current; and

8 a feedback resistor coupled between the internal-feedback nodes.

1 10. The apparatus of claim 1 further comprising:

2 a low-noise amplifier (LNA) to amplify and provide a received RF signal
3 to the mixer; and
4 a voltage buffer to receive the filtered baseband-differential signal from
5 the GmC filter to provide an output differential signal to an analog-to-digital
6 converter (ADC).

1 11. The apparatus of claim 10 wherein the mixer is an in-phase (I)

2 channel mixer to generate an I-channel baseband-differential signal, the GmC
3 filter is an I-channel GmC filter and the voltage buffer is an I-channel voltage
4 buffer to receive the filtered I-channel baseband-differential signal from the I-
5 channel GmC filter, and

6 wherein the receiver further comprises:

7 a quadrature-phase (Q) channel mixer to generate a Q-channel baseband-
8 differential signal;

9 a Q-channel GmC filter to filter the Q-channel baseband-differential
10 signal; and

11 a Q-channel voltage buffer to receive the filtered Q-channel baseband-
12 differential signal and provide a Q-channel output differential signal to the ADC.

1 12. The apparatus of claim 11 wherein the Q-channel GmC filter

2 comprises:

3 first and second Q-channel voltage-dependent capacitors coupled
4 respectively between differential inputs of at least one Q-channel
5 transconductance-capacitor circuit and first and second internal-feedback nodes
6 of the at least one Q-channel transconductance-capacitor circuit,

7 wherein during operation of the Q-channel GmC filter, a substantially-
8 constant bias voltage is to be maintained across the Q-channel voltage-dependent
9 capacitors to allow the Q-channel voltage-dependent capacitors to provide a
10 substantially constant capacitance.

1 13. The apparatus of claim 10 wherein the RF signal comprises signals at
2 either approximately 2.4 GHz or 5.0 GHz.

1 14. The apparatus of claim 10 wherein the RF signal comprises wideband
2 code-division multiple access (WCDMA) signals.

1 15. The apparatus of claim 10 wherein the RF signal comprises
2 orthogonal frequency division multiplexed signals having symbol-modulated
3 orthogonal subcarriers.

1 16. An apparatus comprising:
2 first and second transconductance-capacitor circuits in series; and
3 a transconductance-feedback circuit in feedback with the second
4 transconductance-capacitor circuit,
5 wherein at least one of either the first or second transconductance-
6 capacitor circuits comprises:
7 cross-coupled pairs of transistors to receive a baseband-differential signal
8 and generate a differential output current; and
9 first and second capacitors coupled respectively between differential
10 inputs of the at least one transconductance-capacitor circuit and first and second
11 internal-feedback nodes of the at least one transconductance-capacitor circuit.

1 17. The apparatus of claim 16 wherein the differential-output current is
2 substantially proportional to a differential-input voltage of the baseband-
3 differential signal, and
4 wherein the at least one of transconductance-capacitor circuit further
5 comprises:
6 first and second current sources coupled respectively to the first and
7 second internal-feedback nodes to draw current through the transistors for
8 generating the differential output current; and
9 a feedback resistor coupled between the internal-feedback nodes.

1 18. The apparatus of claim 17 wherein the capacitors are voltage-
2 dependent capacitors, and
3 wherein during operation of the GmC filter, a substantially-constant bias
4 voltage is to be maintained across the voltage-dependent capacitors to allow the
5 voltage-dependent capacitors to provide a substantially constant capacitance.

1 19. The apparatus of claim 18 wherein the voltage-dependent capacitors
2 comprise metal-oxide-semiconductor capacitors (MOSCAPs), wherein the
3 substantially-constant bias voltage allows the MOSCAPs to be operated in a
4 high-density and low-variation portion of the voltage-dependent capacitors'
5 capacitance-response curve to provide a substantially constant capacitance as a
6 function of voltage thereacross.

1 20. The apparatus of claim 18 wherein the transistors of the cross-
2 coupled pairs comprise bipolar junction transistors (BJTs), and wherein the
3 substantially-constant bias voltage is approximately $2V_{BE}$ during the operation of
4 the GmC filter.

1 21. The apparatus of claim 18 wherein the first transconductance-
2 capacitor circuit is to provide a first pole for the GmC filter, and
3 wherein the second transconductance-capacitor circuit and the
4 transconductance-feedback circuit are to provide a second pole of the GmC filter.

1 22. The apparatus of claim 18 wherein the transconductance-feedback
2 circuit is a second transconductance-feedback circuit, and
3 wherein the GmC filter further comprises:
4 an input transconductance circuit; and
5 a first transconductance-feedback circuit in feedback with the first
6 transconductance-capacitor circuit.

1 23. An apparatus comprising first and second current-mode
2 transconductance-resistor-capacitor (GmRC) circuits to receive differential input
3 currents respectively from first and second input transconductance circuits and to

4 generate differential output currents for combining respectively with differential
5 output currents from third and fourth input transconductance circuits to generate
6 respectively in-phase (I) channel and quadrature-phase (Q) channel output
7 differential voltage signals.

1 24. The apparatus of claim 23 wherein the input transconductance circuits
2 respectively are to receive I-channel and Q-channel differential baseband voltage
3 signals and are to generate differential currents proportional to the received
4 differential-baseband signals.

1 25. The apparatus of claim 22 wherein the GmRC circuits comprise:
2 a plurality of cross-coupled transistors;
3 first and second feedback resistors having a value of R; and
4 voltage-dependent capacitors DC to be biased by some of the transistors
5 to operate in a linear region and having a value of C/2,
6 wherein the filter is to reject an image frequency at approximately
7 $1/2pRC$.

1 26. An apparatus comprising:
2 a plurality of cross-coupled transistors to receive a differential input
3 current;
4 first and second feedback resistors coupled between some of the
5 transistors; and
6 voltage-dependent capacitors to be biased by the transistors to operate in
7 a linear region to integrate the received differential input current.

1 27. The apparatus of claim 26 wherein the voltage-dependent capacitors
2 have a value of C/2, and wherein the first and second feedback resistors have a
3 value of R, and
4 wherein a differential-output current is to be provided based on the
5 differential input current, the differential-output current to be further inversely
6 proportional to R and C.

1 28. The apparatus of claim 27 further comprising a plurality of current
2 sources to draw the bias current through the plurality of cross coupled transistors
3 and to provide a substantially-constant bias voltage across the voltage-dependent
4 capacitors.

1 29. A system comprising:
2 an omnidirectional antenna to receive an RF signal;
3 in-phase (I) channel and quadrature-phase (Q) channel mixers to convert
4 the received RF signal to baseband-differential signals; and
5 I and Q-channel transconductance-capacitor (GmC) filters to filter the
6 baseband-differential signal, wherein the GmC filters comprise:
7 first and second transconductance-capacitor circuits in series and a
8 transconductance-feedback circuit in feedback with the second
9 transconductance-capacitor circuit.

1 30. The system of claim 29 further comprising a low-noise amplifier
2 (LNA) to amplify and provide the received RF signal to the I-channel mixer and
3 the Q-channel mixer.

1 31. The system of claim 29 wherein at least one of either the first or
2 second transconductance-capacitor circuits comprises:
3 cross-coupled pairs of transistors to receive the baseband-differential
4 signal and generate a differential output current; and
5 first and second voltage-dependent capacitors coupled respectively
6 between differential inputs of the at least one transconductance-capacitor circuit
7 and first and second internal-feedback nodes of the at least one
8 transconductance-capacitor circuit.

1 32. The system of claim 31 wherein a substantially-constant bias voltage
2 is to be maintained across the voltage-dependent capacitors to allow the voltage-
3 dependent capacitors to maintain a substantially constant capacitance.

1 33. The system of claim 31 further comprising:
2 an analog-to-digital converter (ADC); and
3 I and Q-channel voltage buffers to receive the filtered baseband-
4 differential signal from the I and Q-channel GmC filters to provide an output
5 differential signal to the ADC.

1 34. The system of claim 33 further comprising an image-rejection filter to
2 reject an image signal from the filtered baseband-differential signal from the I
3 and Q-channel GmC filters.

1 35. The system of claim 34 wherein the image rejection filter comprises a
2 first-order poly-phase filter comprising current-mode transconductance-resistor-
3 capacitor (GmRC) circuits to receive differential input currents respectively from
4 the first and second input transconductance circuits and generate differential
5 output currents for combining respectively with differential output currents from
6 third and fourth input transconductance circuits to generate I and Q output
7 differential voltage signals.

1 36. The system of claim 35 wherein the input transconductance circuits
2 respectively to receive I and Q-channel differential baseband voltage signals and
3 to generate differential currents proportional to the received differential-
4 baseband signals.

1 37. The system of claim 35 wherein the GmRC circuits comprise:
2 a plurality of cross-coupled transistors;
3 first and second feedback resistors having a value of R; and
4 voltage-dependent capacitors DC to be biased by some of the transistors
5 to operate in a linear region and having a value of C/2,
6 wherein the image-rejection filter to at least partially reject an image
7 frequency at approximately $1/2pRC$.